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1. Marjan. Masoomifard<sup>1</sup>: Associate Professor, Department of Educational Sciences, Payame Noor University (PNU), Tehran, Iran (Email: dr.masoomifard@pnu.ac.ir)
2. Mahsa. Masoomifard<sup>2</sup>: MA degree graduate, Department of Public Administration, University of Tehran, Tehran, Iran
3. Ziba. Nouri<sup>3</sup>: Assistant Professor, Department of Educational Sciences, Payame Noor University (PNU), Tehran, Iran
4. Abbas. Shayestehfar<sup>4</sup>: Assistant Professor, Department of Educational Sciences, Payame Noor University (PNU), Tehran, Iran

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# Analysis of the Effectiveness of Peer-Assisted and Teacher-Centered Instruction on Mathematics Performance and Resilience in Learning Mathematics

## ABSTRACT

The present study aimed to compare the effects of peer-assisted instruction and teacher-centered instruction on mathematics performance and resilience in learning mathematics. In terms of purpose, this research was applied; in terms of nature, it employed a quasi-experimental pretest–posttest design; and in terms of implementation, it was conducted using a survey approach. The statistical population consisted of all fifth-grade female elementary school students in District 7 of Tehran during the 2021–2022 academic year. Participants were selected through multistage cluster random sampling. Two classes were chosen as the research sample, with 30 students in each class. In one class, mathematics was taught using the peer-assisted (collaborative) instructional method, while in the other class, mathematics was taught using the teacher-centered (traditional) instructional method. Data collection instruments included a standardized mathematics achievement test to assess the learning variable and the Mathematics Resilience Scale developed by Kooken et al. (2016) to measure resilience in learning mathematics. The validity and reliability of both instruments were examined and confirmed. The results of the analysis of covariance (ANCOVA) indicated that the peer-assisted instructional method had a significant effect on mathematics performance and resilience in learning mathematics among fifth-grade elementary school students.

**Keywords:** Peer-assisted instruction, teacher-centered instruction, mathematics performance, resilience in learning mathematics.

## Introduction

Mathematics education constitutes a foundational component of cognitive development and problem-solving skills in students, influencing their academic success and future learning trajectories. Recent research emphasizes the importance of

instructional strategies that actively engage learners to foster both cognitive achievement and affective outcomes in mathematics classrooms (1, 2). Among these strategies, peer-assisted learning and cooperative instructional approaches have garnered attention due to their potential to enhance academic performance through social interdependence and collaborative engagement (3-5). Cooperative learning, in particular, has been shown to promote higher mathematics achievement, positive attitudes toward the subject, and improved peer relationships, creating a classroom environment conducive to both cognitive and emotional resilience (6-8).

Peer-assisted learning leverages structured interaction among students, allowing learners to assume both teaching and learning roles, which encourages active participation, discussion, and mutual support (9-11). Empirical studies suggest that students engaged in peer-based learning environments demonstrate increased motivation, engagement, and academic self-efficacy, which subsequently improve overall achievement (12, 13). These findings align with social interdependence theory, which posits that positive interdependence among learners fosters cooperative behaviors, accountability, and individual effort toward collective learning goals (3, 4). Furthermore, peer-mediated instruction has been linked to increased problem-solving skills, deeper conceptual understanding, and greater retention of mathematical content compared with traditional teacher-centered approaches (6, 14).

Mathematical resilience, defined as students' capacity to persevere and effectively manage challenges in learning mathematics, has emerged as a critical affective construct in recent decades (15, 16). Research highlights that resilience can be nurtured through instructional methods that balance challenge with support, enabling learners to develop coping strategies and maintain engagement despite difficulties (17, 18). Cooperative and peer-assisted instructional approaches, by creating opportunities for collaborative problem-solving, feedback exchange, and emotional support, have been identified as effective mechanisms for fostering resilience in mathematics learners (2, 14). In addition, promoting resilience through interactive learning environments can reduce mathematical anxiety and helplessness, thereby improving long-term persistence and achievement in mathematics (15, 17).

The effectiveness of peer-assisted learning in mathematics is also reinforced by meta-analytic and experimental evidence demonstrating higher achievement outcomes relative to conventional, teacher-centered methods (5-7). Studies across diverse educational contexts indicate that collaborative learning not only enhances content mastery but also strengthens peer networks, encourages shared responsibility, and supports motivation and engagement in the learning process (3, 4, 9). For example, Shao et al. (2024) demonstrated that peer relationships positively influence academic performance via learning motivation and engagement among junior high students, highlighting the cascading effect of social interaction on both affective and cognitive outcomes (10). Similarly, Murphy et al. (2024) reported that optimized peer-based learning environments increase student participation and collaborative problem-solving, reinforcing the value of structured peer support in mathematics education (13).

The integration of peer-assisted learning strategies within elementary mathematics classrooms also aligns with broader educational frameworks advocating active learning and student-centered pedagogies. Active learning, characterized by engagement, discussion, and reflection, has consistently been associated with superior academic outcomes in STEM education (1, 2). Cooperative learning methods, such as Student Teams-Achievement Divisions (STAD) and Team Assisted Individualization (TAI), facilitate structured collaboration that encourages students to support each other while working toward individual and group goals, which enhances both achievement and resilience (6, 7). Furthermore, meta-analyses confirm that students in cooperative learning settings report higher attitudes toward mathematics, reduced anxiety, and improved self-regulatory skills compared with peers in teacher-led environments (5, 8, 14).

Finally, research also underscores the mediating role of peer relationships and engagement in the development of both academic performance and resilience. Lombres (2024) found that academic self-efficacy and peer relationships mediate the

relationship between learning engagement and achievement, indicating that effective peer collaboration can amplify the impact of instructional strategies (12). Fitri (2024) similarly emphasized that the motivational benefits of peer interaction are globally significant, particularly in elementary education where social and cognitive development are tightly linked (9). Collectively, the body of literature suggests that implementing peer-assisted and cooperative instructional methods can foster both the cognitive and affective domains of mathematics learning, providing students with the tools to succeed academically while developing resilience to overcome challenges in learning mathematics (16-18).

Based on this literature, the aim of the present study is to compare the effect of peer-assisted instruction with teacher-centered instruction on mathematics performance and resilience in learning mathematics among fifth-grade elementary students.

## Methods and Materials

The present study employed a quasi-experimental design with two groups and a pretest–posttest implementation. The statistical population consisted of all fifth-grade female elementary school students in District 7 of Tehran, totaling 1,170 students during the 2021–2022 academic year. Sampling was conducted using multistage cluster random sampling. In the first stage, several girls' elementary schools in District 7 of Tehran were randomly selected. In the second stage, fifth-grade classes within the selected schools were randomly chosen as research clusters. In the third stage, two classes were randomly selected from the chosen clusters, and pretests were administered to both. The mean pretest scores of the two groups were compared, and students were assigned to two homogeneous classes: one class of 30 students for mathematics instruction using the peer-assisted method, and one class of 30 students for mathematics instruction using the teacher-centered method, totaling 60 students. Both groups received instruction over twelve sessions according to their respective methods.

The inclusion criterion for participation was full parental consent for attendance in the instructional sessions, and the exclusion criterion was absence from more than two sessions. Data collection instruments included a standardized mathematics achievement test, whose content and face validity were confirmed by five teachers with over 20 years of experience, and reliability was established using Cronbach's alpha at 0.87. Additionally, the Mathematics Resilience Scale developed by Kookan et al. (2016) was used to assess students' ability to cope with difficulties in learning mathematics; its validity was confirmed by five educational sciences faculty members, and reliability was determined using Cronbach's alpha at 0.89.

The implementation procedure was as follows: before the start of instruction in both classes, an orientation session was held for the teachers to clarify the teaching methods. The teachers then explained their respective instructional methods to their students. After preparing both classes, pretests were administered to both groups, and students were assigned to homogeneous classes. Mathematics instruction then began in each class using the designated method. The experimental class received peer-assisted (collaborative) instruction over twelve sessions, while the control class received teacher-centered instruction over twelve sessions. Following the twelve instructional sessions, posttests were administered. Data analysis was performed using SPSS version 21. Descriptive statistics included mean and standard deviation. For inferential statistics, the normality of the data distribution was assessed through skewness and kurtosis, and research questions were addressed using analysis of covariance (ANCOVA) at a significance level of 0.05, after testing for homogeneity of variances and homogeneity of regression slopes using Levene's test.

## Findings and Results

Table 1 presents the descriptive statistics for mathematics performance and resilience in learning mathematics in the pretest and posttest stages for the peer-assisted and teacher-centered instructional groups.

**Table 1. Descriptive Statistics of Mathematics Performance and Resilience in Learning Mathematics**

Variable	Time	Teacher-Centered (n=30) Mean $\pm$ SD	Peer-Assisted (n=30) Mean $\pm$ SD
Resilience in Learning Mathematics	Pretest	2.15 $\pm$ 0.86*	2.15 $\pm$ 0.86*
	Posttest	2.46 $\pm$ 0.82	3.86 $\pm$ 0.35
Mathematics Performance	Pretest	10.15 $\pm$ 3.12*	10.15 $\pm$ 3.12*
	Posttest	13.33 $\pm$ 2.13	17.93 $\pm$ 1.61

As shown in Table 1, the mean score of resilience in learning mathematics increased from 2.15 at pretest to 2.46 at posttest in the teacher-centered group, whereas the corresponding score in the peer-assisted group increased to 3.86. Similarly, mathematics performance improved from a pretest mean of 10.15 to 13.33 in the teacher-centered group and to 17.93 in the peer-assisted group. These descriptive findings suggest that students who received peer-assisted instruction demonstrated greater improvement in both mathematics performance and resilience in learning mathematics compared with students who received teacher-centered instruction.

Before conducting the main analysis, the assumptions of ANCOVA were examined. Assessment of normality through skewness and kurtosis indicated that all values fell within the acceptable range of  $\pm 2$ , supporting the assumption of normal distribution. Levene's test showed that the homogeneity of variance assumption was satisfied for mathematics performance ( $F = 0.054$ ,  $p = .817$ ) and resilience in learning mathematics ( $F = 1.45$ ,  $p = .085$ ). In addition, the interaction between the covariate and group membership was not statistically significant for mathematics performance ( $p = .074$ ) or resilience in learning mathematics ( $p = .069$ ), indicating that the assumption of homogeneity of regression slopes was met. Therefore, the use of ANCOVA was considered appropriate.

**Table 2. ANCOVA Results for Mathematics Performance and Resilience in Learning Mathematics**

Variable	Source	SS	df	MS	F	p
Mathematics Performance	Teaching Method	165.697	1	165.697	28.835	.000
	Pretest	1017.302	1	1017.302	177.033	.000
	Error	327.545	57	5.746		
Resilience in Learning Mathematics	Teaching Method	11.293	1	11.293	38.259	.000
	Pretest	4.042	1	4.042	13.695	.000
	Error	16.824	57	0.295		

The ANCOVA results presented in Table 2 indicate that, after controlling for pretest scores, the effect of instructional method on mathematics performance was statistically significant,  $F(1, 57) = 28.835$ ,  $p < .001$ . Thus, students who were taught using the peer-assisted instructional method achieved significantly higher mathematics performance scores than those who were taught using the teacher-centered method. Furthermore, the effect of instructional method on resilience in learning mathematics was also statistically significant,  $F(1, 57) = 38.259$ ,  $p < .001$ . Accordingly, students in the peer-assisted instruction group demonstrated significantly greater resilience in learning mathematics than students in the teacher-centered instruction group. Overall, the findings support the effectiveness of peer-assisted instruction in enhancing both mathematics performance and resilience in learning mathematics among fifth-grade elementary school students.

## Discussion and Conclusion

The present study aimed to compare the effectiveness of peer-assisted instruction and teacher-centered instruction on mathematics performance and resilience in learning mathematics among fifth-grade elementary school students. The findings demonstrated that peer-assisted instruction had a significant positive effect on both mathematics performance and resilience in learning mathematics. Students who participated in the peer-assisted instructional approach achieved significantly higher

posttest scores in mathematics performance and exhibited greater resilience in learning mathematics compared with students who received teacher-centered instruction. These findings suggest that collaborative learning environments provide substantial advantages over traditional instructional approaches in facilitating both academic and affective outcomes in mathematics education.

The first major finding of the study indicated that peer-assisted instruction significantly improved students' mathematics performance. After controlling for pretest scores, students in the peer-assisted group obtained significantly higher mathematics achievement scores than those in the teacher-centered group. This finding is consistent with a substantial body of literature emphasizing the effectiveness of cooperative and peer-based learning strategies in mathematics education (5, 6). The improvement observed in mathematics performance can be attributed to the active learning opportunities inherent in peer-assisted instruction. Unlike teacher-centered approaches, which often position students as passive recipients of information, peer-assisted learning requires students to actively engage in discussion, explanation, questioning, and collaborative problem-solving. Such activities promote deeper cognitive processing and facilitate the construction of mathematical knowledge through social interaction (3, 14).

The findings align with those of Tarim and Akdeniz, who reported that cooperative learning methods significantly improved elementary students' mathematics achievement and attitudes toward mathematics (7). Similarly, Zakaria and colleagues found that students participating in cooperative mathematics instruction demonstrated superior achievement compared with students receiving conventional instruction (8). The current results also support the conclusions of the meta-analysis conducted by Capar and Tarim, which identified consistent positive effects of cooperative learning on mathematics achievement across educational settings (6). The consistency of these findings across studies suggests that collaborative instructional methods constitute a robust pedagogical strategy for enhancing mathematical learning outcomes.

From a theoretical perspective, the positive effect of peer-assisted instruction on mathematics performance can be explained through social interdependence theory. According to Johnson and Johnson, cooperative learning creates positive interdependence among students, whereby individual success is linked to group success, encouraging mutual support and shared responsibility for learning (3). In such contexts, students benefit from receiving explanations from peers, observing alternative problem-solving strategies, and verbalizing their own mathematical reasoning. These processes contribute to conceptual understanding and facilitate the correction of misconceptions, leading to improved academic performance. Roseth and colleagues similarly demonstrated that cooperative goal structures enhance both academic achievement and peer relationships, highlighting the importance of social interaction in educational success (4).

Another explanation for the observed improvement in mathematics performance concerns the role of active engagement. Freeman and colleagues demonstrated that active learning strategies produce significantly greater achievement gains in science, engineering, and mathematics than traditional lecture-based instruction (2). Peer-assisted instruction inherently incorporates active learning by encouraging students to participate directly in learning activities rather than merely listening to teacher explanations. Through discussion and collaboration, students continuously process information, evaluate alternative solutions, and refine their understanding of mathematical concepts. Consequently, learning becomes more meaningful and durable, leading to higher levels of achievement.

The second major finding revealed that peer-assisted instruction significantly enhanced resilience in learning mathematics. Students exposed to peer-assisted learning demonstrated substantially higher levels of mathematical resilience than those taught through teacher-centered instruction. This finding is particularly important because resilience has emerged as a critical factor influencing students' long-term engagement, persistence, and success in mathematics education (16, 18). Mathematical

resilience refers to students' capacity to persist when confronted with challenges, cope effectively with failure, and maintain confidence in their ability to learn mathematics despite difficulties (15).

The results are consistent with previous research emphasizing the importance of supportive social environments in fostering mathematical resilience. Goodall and Johnston-Wilder argued that resilience develops when learners experience opportunities to overcome challenges within supportive contexts that encourage risk-taking and persistence (17). Peer-assisted instruction creates precisely such an environment. Students work collaboratively to solve problems, exchange ideas, and support one another during moments of difficulty. This shared learning experience reduces feelings of isolation and anxiety while promoting confidence and persistence. Consequently, students become more willing to engage with challenging mathematical tasks and develop stronger beliefs in their capacity to succeed.

The findings also correspond with the systematic review conducted by Heyd-Metzuyanim and colleagues, which identified social support, positive learning experiences, and collaborative engagement as key contributors to mathematical resilience (18). Through peer interaction, students receive immediate feedback, emotional encouragement, and opportunities to observe peers successfully navigating mathematical challenges. Such experiences reinforce adaptive beliefs about learning and help students view mistakes as opportunities for growth rather than indicators of failure. As a result, resilience is strengthened and students become better equipped to manage the demands of mathematics learning.

Furthermore, the enhancement of resilience may be explained through the motivational mechanisms associated with positive peer relationships. Recent studies have demonstrated that peer relationships significantly influence academic motivation, engagement, and achievement (10, 12). When students perceive their peers as supportive collaborators, they are more likely to participate actively, persist during difficulties, and invest effort in learning tasks. Shao and colleagues reported that peer relationships influence achievement through their effects on learning motivation and engagement (10). Similarly, Lombres found that peer relationships contribute to academic self-efficacy and engagement, which are closely linked to resilience (12). Therefore, the increased resilience observed in the present study may partly reflect improvements in students' motivation, confidence, and engagement resulting from positive peer interactions.

Another important consideration is the role of peer-assisted learning in reducing mathematics anxiety and helplessness. Previous studies have shown that negative emotional experiences often undermine students' confidence and willingness to engage with mathematical challenges (15, 17). In traditional teacher-centered classrooms, students may hesitate to ask questions or admit misunderstandings due to fear of negative evaluation. In contrast, peer-assisted learning provides a less threatening environment in which students can seek clarification, share uncertainties, and receive support from classmates. Such interactions reduce anxiety and foster a sense of competence, thereby contributing to greater resilience and persistence.

The current findings also resonate with contemporary research emphasizing the educational value of peer-based learning environments. Murphy and colleagues highlighted the capacity of peer learning environments to optimize engagement, knowledge construction, and learner autonomy (13). Similarly, Fitri and Astuti emphasized the powerful role of peers in motivating elementary learners and promoting meaningful learning experiences (9). The present study extends this body of evidence by demonstrating that peer-assisted instruction not only enhances academic achievement but also strengthens psychological resources essential for sustained learning success.

Moreover, the results support recent evidence from online and blended learning contexts indicating that peer interaction can significantly enhance learning outcomes. Rezai and colleagues demonstrated that peer-dynamic assessment improved students' writing performance through collaborative feedback and interaction (11). Although conducted in a different subject area, their findings reinforce the broader principle that structured peer interaction facilitates learning by creating opportunities for

reflection, feedback, and shared problem-solving. These mechanisms are equally relevant in mathematics education and likely contributed to the positive outcomes observed in the present study.

Taken together, the findings suggest that peer-assisted instruction represents a highly effective pedagogical approach capable of addressing both cognitive and affective dimensions of mathematics learning. By promoting active engagement, social interaction, motivation, and resilience, peer-assisted learning creates conditions that facilitate deeper understanding and greater persistence in the face of challenges. In contrast, teacher-centered instruction, while effective for delivering content, may provide fewer opportunities for collaborative meaning-making and emotional support. Consequently, peer-assisted approaches appear particularly valuable for fostering comprehensive educational development among elementary school students.

Several limitations should be considered when interpreting the findings of this study. First, the sample consisted exclusively of fifth-grade female students from a single educational district, which may limit the generalizability of the findings to other age groups, educational levels, and geographical regions. Second, the intervention was conducted over a relatively short period of twelve instructional sessions, preventing the assessment of long-term effects on mathematics performance and resilience. Third, the study relied primarily on quantitative measures and did not examine students' subjective experiences of peer-assisted learning. Finally, potential influences such as teacher characteristics, classroom climate, and family support were not controlled and may have affected the observed outcomes.

Future studies should examine the effectiveness of peer-assisted instruction across different grade levels, genders, and cultural contexts to determine the broader applicability of the findings. Researchers may also investigate the long-term sustainability of gains in mathematics performance and resilience through follow-up assessments conducted several months after the intervention. Additionally, qualitative and mixed-methods approaches could provide deeper insights into students' experiences, perceptions, and interactions within peer-assisted learning environments. Future research may further explore the mechanisms through which peer-assisted instruction influences resilience, including the roles of self-efficacy, motivation, engagement, and mathematics anxiety.

Educational practitioners are encouraged to incorporate structured peer-assisted learning activities into mathematics instruction at the elementary level. Schools may provide professional development opportunities to help teachers design and facilitate effective collaborative learning environments. Mathematics curricula should include tasks that require discussion, cooperation, and joint problem-solving among students. Teachers can promote resilience by encouraging students to view mistakes as learning opportunities and by creating supportive classroom cultures that emphasize persistence and mutual assistance. Educational policymakers may also consider integrating cooperative learning principles into instructional guidelines and curriculum frameworks to enhance both academic achievement and students' capacity to cope with learning challenges.

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### **Authors' Contributions**

All authors equally contributed to this study.

### **Declaration of Interest**

The authors of this article declared no conflict of interest.

## Ethical Considerations

All ethical principles were adhered in conducting and writing this article.

## Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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